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Original Article

IoT-Based Air Quality Management in Somalia

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Abstract *- Air pollution in Somalia is a serious threat to human health, agriculture, and the environment and requires immediate attention. The DSM501A PM2.5 sensor, Raspberry Pi, IoT, and cloud computing are all used in this study to create a comprehensive air quality monitoring system. The system's architecture allows for measuring particulate matter and environmental characteristics, allowing for a more comprehensive approach to pollution management. The study highlights the efficiency of merging IoT and cloud computing for real-time data gathering, processing, and display by exploiting the versatility of the Raspberry Pi. The created approach fills a critical gap in existing monitoring frameworks by focusing on particulate matter. It stresses the importance of public awareness and international engagement in mitigating air pollution in Somalia. The suggested system is suited for deployment in various geographic and economic scenarios due to key aspects such as cost, energy efficiency, and scalability. In the midst of worldwide air quality challenges, the findings highlight the relevance of data-driven solutions in protecting human health, promoting environmental sustainability, and boosting community well-being. This study advances air quality monitoring methods and calls for comprehensive air pollution control tactics in Somalia.*

Keywords *- Air pollution, IoT, Raspberry Pi, DSM501A PM2.5 sensor, Cloud.*

1. Introduction

The abundance of particulate matter, hazardous compounds, and living molecules in Somalia's atmosphere causes air pollution [1]. This environmental dilemma has far-reaching consequences, harming humans, animals, and agricultural products and endangering both urban and natural landscapes. Air pollution in Somalia can cause increased allergies, higher chances of significant health issues such as cardiovascular and respiratory disorders, and, in extreme situations, death. Though particular data for Somalia may be difficult to come by, it is critical to recognize the possible impact of air pollution on the people. Efforts should be focused on conducting studies and assessments to determine the scope of the problem in the country [2]. It is critical to address this issue to protect the Somali people's well-being, their environment, and the region's general sustainability.

Public awareness campaigns and international cooperation may be essential to combat and mitigate Somalia's air pollution. Through an awareness of the causes of pollution and implementing practical solutions like stricter emission regulations and the promotion of cleaner technology, Somalia can endeavor to create a more sustainable and healthier environment for its people. Particulate matter is the term for tiny, liquid or solid particles suspended in the Earth's atmosphere [3]. Numerous investigations into a range of variables, such as temperature, humidity, barometric air pressure, sulfur dioxide, and carbon monoxide, have been carried out in the field of environmental monitoring [4]. However, it is important to note that particle matter detection has not received much attention in this research.

To effectively monitor air quality, one must have a thorough understanding of atmospheric particulate matter concentrations. To tackle this pressing problem, a system utilizing a DSM501A PM2.5 sensor has been created. In addition to this system, sensors monitor barometric air pressure, temperature, humidity, and carbon dioxide and carbon monoxide levels. These sensors can be used in conjunction with a Raspberry Pi [5], an incredibly adaptable, reasonably priced, and low-power computer.

The Raspberry Pi is a great platform for multi-device connections. This system makes use of both cloud computing and the Internet of Things (IoT). Devices can perceive, recognize, process, and communicate with one another on their own, according to the Internet of Things concept [6]. On the other hand, cloud computing uses other servers to supply resources like virtual computers, storage, apps, and utilities over the internet, negating the need for internal infrastructure upkeep [7]. When cloud computing and the Internet of Things are combined, their potential increases. An IoT cloud system facilitates cloud deployment and operation by offering easy access to IoT resources and capabilities through defined APIs.

Since cloud data is always accessible, scenario analysis can be performed more effectively. This analytical proficiency assists in improving air pollution mitigation strategies to some extent [8]. IoT and cloud computing appear to be powerful tools for enhancing pollution control and air quality monitoring.

As described, the development and roll-out of a detailed air quality monitoring system represents an important step toward understanding and minimizing the impact of particulate matter on human health and the environment. Particulate matter, which has often been neglected in prior environmental monitoring studies, is critical in determining air quality [9]. Its tiny nature and potential health consequences highlight the importance of including specific PM sensors in monitoring frameworks. The use of the DSM501A PM sensor, when combined with other sensors for environmental parameters on a Raspberry Pi platform, shows a strategic convergence of technology advances. The characteristics of the Raspberry Pi make it a versatile hub for controlling multiple sensors simultaneously, displaying the agility required for effective environmental monitoring [10].

Aside from its technological competence, this configuration demonstrates a dedication to affordability and energy efficiency, both of which are key elements for widespread deployment in various geographic and economic circumstances. The addition of the Internet of Things (IoT) and cloud computing increases the system's potential even further.

The Internet of Things' autonomous sensing and communication capabilities improve real-time data collecting, allowing for a more dynamic knowledge of air quality variations. Cloud computing, with its distant server infrastructure, not only makes data storage easier but also allows for more advanced data analysis. This collaboration enables the development of predictive models and data-driven solutions, both of which are critical components in the ongoing fight against air pollution [11].

A significant study gap in existing studies is the concentration on particulate matter detection in environmental monitoring initiatives [12]. While several environmental variables such as temperature, humidity, barometric air pressure, sulfur dioxide, and carbon monoxide have been thoroughly studied [13], particulate matter, which is crucial for assessing air quality, has received inadequate attention. This study identifies and resolves this gap, emphasizing the need to understand particulate matter concentrations in the atmosphere for a thorough air quality assessment [14].

This study is unusual because it introduces a specific method for monitoring air quality that merges a DSM501A PM2.5 sensor with a Raspberry Pi platform [15]. Unlike other studies, which may overlook particle matter, this study focuses specifically on its detection. Using the Raspberry Pi as a central hub for several sensors demonstrates technological efficiency and agility, resulting in an innovative environmental monitoring method [16]. Furthermore, using the Internet of Things (IoT) and cloud computing enhances the research's innovation by enabling autonomous sensing, communication capabilities, and enhanced data analysis for a more dynamic knowledge of air quality variations [17].

Compared to previous studies, this work addresses a substantial gap by addressing the often-disregarded aspect of particulate matter detection in environmental monitoring. While many studies have investigated many environmental variables, the use of PM sensors, notably the DSM501A, provides a more nuanced perspective on air quality assessment [18]. Using Raspberry Pi as a central hub for various sensors increases the system's versatility, displaying a dedication to technological efficiency and agility necessary for successful environmental monitoring [19].

In addition, integrating the Internet of Things (IoT) and cloud computing expands the research's potential by bringing autonomous sensing and communication capabilities, allowing for real-time data collecting and offering dynamic insights into air quality variations [20]. This collaboration, which emphasizes cloud computing's remote server infrastructure, not only streamlines data storage but also offers up possibilities for advanced data analysis, such as the development of predictive models and data-driven solutions critical in the ongoing fight against air pollution [21].

2. Literature Review

Researchers have studied various novel techniques to improve our understanding and management of environmental conditions in air quality monitoring. Phala, kgoputjo, and colleagues [22] made major contributions by presenting an Air Quality Monitoring System (AQMS) based on the IEEE/ISO/IEC 21451 standard. The standardized base provides a steady and uniform framework for evaluating important pollutants such as CO, CO_2, SO_2, and NO_2. The accuracy of the data acquired is increased by employing infrared and electrochemical sensors for measurement. The results are effectively recorded in a centralized data server for in-depth examination.

Xing Liu and Orlando examined the intricacies of the Internet of Things (IoT) [23], with a particular focus on intelligent sensors, objects, devices, and things. In addition to elucidating IoT definitions and ideas, their comparative research provides a comprehensive examination of the distinctions and similarities among smart objects and things inside the IoT ecosystem. The tabular structure of this data facilitates the integration of different points of view and methodologies pertaining to the Internet of Things, hence augmenting comprehension of the expanding landscape within this technological domain. Real-time monitoring was provided by Marinov, Marin B., et al. [24] using infrared gas sensors and amperometric sensors powered by the PIC18F87K22 microprocessor. Continuous environmental factor monitoring is made possible by the thoughtful deployment of sensor nodes in various locations.

The presentation of data on a city map not only provides a broad overview but also enables localized analysis, allowing for rapid response to developing patterns or issues. Baralis, Elena, and colleagues [25] developed a Business Intelligence Engine (APA) to increase public awareness. While not specifically stated, this system emphasizes the multifaceted nature of air quality monitoring. By using business intelligence concepts, it aims to gather, process, and provide data and insightful information to the public. This strategy fits with the emerging concept of giving communities useful information to encourage a sense of environmental responsibility.

The necessity of setting up networks for monitoring air quality has prompted the development of novel tools, instruments, and methods for determining and evaluating the concentrations of air pollutants. This part explores a cutting-edge analysis of relevant research, emphasizing two different air quality assessment methods. By offering an air quality monitoring system that makes use of IoT sensors and long-range communication, Thu et al. [26] advance the field. Their study uses a commercial solution from Telaire that combines a sensor package that measures temperature, humidity, dust, and carbon dioxide (CO_2) with an Arduino Uno microcontroller with a long-range LoRa module. The research highlights implementing LoRA technology in the Low-Power Wide Area Network (LPWAN) to establish a resilient network infrastructure.

MQTT is the preferred communication protocol for this purpose. Although machine learning is discussed as a means of forecasting measured indices, the work focuses mostly on temperature and humidity, with the potential for expanding the technique's applicability to other contaminants. Huang et al. [27] provide a platform for detecting the quantity of PM2.5 and gases such as formaldehyde (CH_2O), carbon monoxide (CO), and CO_2. The device features an electronic circuit board that integrates several sensors, giving it an advanced hardware design. Notably, the ESP-07 microcontroller and nRF51822 chip provide wireless networking on the platform. The technology enables real-time data display on cell phones and is geared for mobile application integration. The lack of cloud storage, which impedes long-term analysis, and the incapacity to set off alarms for elevated pollutant concentrations are drawbacks.

Ladekar et al. [28] suggest an Internet of Things (IoT) solution that measures O_2, CO_2, and PM2.5 pollutants and air quality. It makes use of an ESP8266 Node-MCU and Raspberry Pi. The prototype has Wi-Fi connectivity to transfer data to a Raspberry Pi serving as an MQTT broker server. While the technique offers an indoor network, it might be worthwhile to reassess how cost-effective employing Raspberry Pi is. The study could benefit from supporting Raspberry Pi's inclusion, and the system doesn't provide users with regular information regarding pollution rates, which may improve proactive response. Air quality is influenced by a number of factors, such as harmful gasses and contaminants. Using the APA, a multifaceted analysis of air pollution is carried out using data from contaminants, traffic, and meteorology.

This technique is essential for helping people become more conscious of how their actions affect the declining quality of the air. A system to model and control the microclimate of metropolitan areas, as well as monitor environmental parameters, has been proposed by Jha, Mukesh et al. [29]. By thoroughly analyzing the urban microclimate, this system's implementation seeks to support the creation of effective urban infrastructure.

Agrawal, S. and Shete, R. [29] propose a framework for using a cost-effective Raspberry Pi device to monitor the urban environment. Temperature, pressure, carbon dioxide, and carbon monoxide are among the factors that are measured. Even so, the environmental monitoring component is lacking since particulate matter is not given enough attention. Mitar Simic, Goran M. et al. have presented a method to evaluate and collect data regarding the attributes related to air and water quality [30]. The system is powered by batteries and a solar panel-based charging apparatus; the IBM Watson IoT platform displays the system's performance.

Xing Liu and Orlando's [31] study on the Internet of Things (IoT) presents an insightful exploration of intelligent sensors, objects, devices, and the broader IoT ecosystem. Their comparative research not only explains IoT concepts and notions but also thoroughly examines the differences and similarities across smart objects and things, promoting a nuanced awareness of this changing technological world. Marinov, Marin B., et al. [32] demonstrate real-time monitoring using infrared gas and amperometric sensors powered by the PIC18F87K22 microprocessor.

The strategic deployment of sensor nodes in multiple locations allows continuous environmental element monitoring. Furthermore, Baralis, Elena, and colleagues [33] put data visualization on a city map, offering a panoramic picture and permitting localized analysis, allowing for quick responses to developing trends or difficulties. Their Business Intelligence Engine (APA) helps raise public awareness, highlighting the varied nature of air quality monitoring and harmonizing with the paradigm shift toward giving communities actionable knowledge to inspire environmental responsibility. Thu et al. [34] give a state-of-the-art evaluation of air quality monitoring, which includes a comprehensive system based on IoT sensors and long-range communication.

The study's focus on designing a Low-Power Wide Area Network (LPWAN) using LoRA technology in conjunction with the messaging protocol Message Queuing Telemetry Transfer (MQTT) results in a robust network design. Although the application of machine learning to forecast monitoring indices is being investigated, Additional research is required to expand these techniques to encompass a wider variety of contaminants.

Huang et al. developed a novel air quality monitoring system that displays real-time smartphone data intended for mobile application integration [35]. However, issues such as a lack of cloud storage impedes long-term analysis and the inability to provide alarms for high pollutant concentrations are highlighted. Ladekar et al.'s [36] IoT solution, which uses Raspberry Pi and Node-MCU ESP8266, presents a potential network for interior situations. However, including the Raspberry Pi may demand further rationale for best cost-effectiveness, and the system could benefit from frequent notifications to improve user awareness and proactive response.

Besides methodological limits, the APA technique, as outlined by Jha, Mukesh, and colleagues [37], presents a comprehensive strategy for studying air pollution from meteorological, pollutant, and traffic data viewpoints. This technique helps to understand the effects of individual actions on air quality and creates the framework for raising environmental awareness among the general public. In parallel, Agrawal, S., and Shete, R. [38] present a low-cost system for monitoring urban air quality using the Raspberry Pi. There is a visible gap in the particulate matter coverage despite the fact that temperature, pressure, carbon dioxide, and carbon monoxide are recorded. This highlights the necessity for a more comprehensive environmental monitoring component.

Last but not least, Mitar Simic, Goran M., et al. [39] provide a novel method that uses batteries and a solar panel-based charging mechanism to assess air and water quality aspects. The results are exhibited on the IBM Watson IoT platform, showcasing a combination of sustainability and technical innovation. This comprehensive overview focuses on the many approaches and technologies used in air quality monitoring, giving the groundwork for a better understanding of the changing situation in this crucial subject.

3. System Architecture

The system is divided into three fundamental layers, according to the Internet of Things (IoT) architecture: the observation layer, the network layer, and the layer that presents data.

3.1. Perception Layer (Sensing Layer)

This fundamental layer acts as the IoT system's entry point, covering sensors and gadgets that collect real-world data. This layer, in the context of air quality monitoring entails the deployment of numerous sensors capable of detecting environmental characteristics such as pollution, temperature, humidity, and other pertinent data points. These sensors serve as the system's eyes and ears, acquiring and relaying critical information about its surroundings.

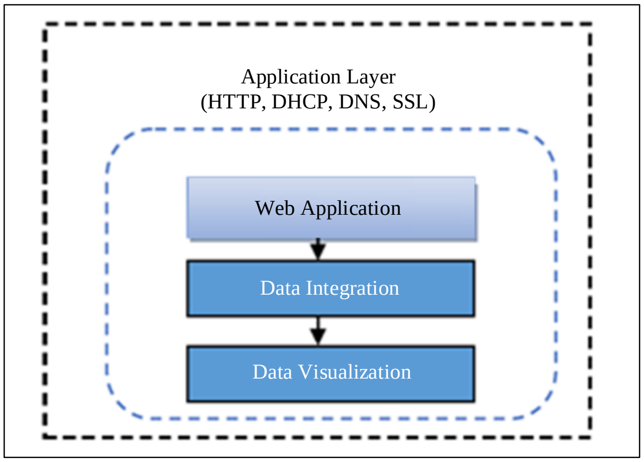

Fig. 1 Application layer design

3.2. Network Layer

The perception layer's data is subsequently relayed through the network layer, which serves as the backbone of communication within the IoT architecture. This layer entails smooth device connectivity, ensuring efficient and secure data transport.

This stage of air quality monitoring systems frequently uses wireless technologies such as Wi-Fi, Bluetooth, or Low-Power Wide Area Networks (LPWAN) to communicate detected data to central processing units or cloud-based servers. The network layer enables real-time analysis and response by facilitating the seamless flow of information.

3.3. Presentation Layer

The presentation layer is the final layer, where the processed data is made accessible and understandable to end users. This layer could involve creating applications, dashboards, or user-friendly interfaces for air quality monitoring.

Visualization techniques like graphs, charts, and geographic maps are often used to present air quality data intelligibly. This layer ensures that stakeholders such as researchers, legislators, and the general public may readily comprehend and act on the IoT system's data.

3.3.1. Raspberry Pi 4 Model B

The Raspberry Pi stands out as a multipurpose single-board computer, surpassing its predecessors in speed and power thanks to a CPU: ARM Cortex A7 with 1 GB of RAM. This version has a quad-core, overclockable Broadcom

BCM2836 processor that runs at 900 MHz. It features an Ethernet port, a full HDMI port, four USB ports, forty GPIO pins, a capability to use composite video and a 3.5 mm audio jack.

Notably, it integrates interfaces such as the Camera Seriel Interface (CSI) and the Display Seriel Interface (DSI) [25], broadening its usefulness in a variety of tasks. The Micro SD card slot on the Raspberry Pi is essential since it stores the operating system and other required applications and peripherals. This feature supports the device's smooth operation while allowing users to adjust the system to their unique needs. Raspbian, Windows 10, Ubuntu, and other operating systems are supported by the Raspberry Pi.

The Raspbian operating system was chosen for the implementation of the described system. The capabilities of Raspberry Pi are supplemented by Node-Red, a visual programming tool built for the Internet of Things (IoT). Noted for its simple UI, Node-Red makes development easier by offering an integrated library with thousands of flows and nodes.

These components facilitate client interaction across a range of devices and services, hence fostering interoperability across IoT ecosystems [26]. A flow may be swiftly implemented after it is created, and dashboards enable the viewing of data in real-time. Integrating Node-Red with Raspberry Pi enhances the effectiveness of Internet of Things applications while showcasing the versatility and accessibility of these technologies in a range of do-it-itself projects.

3.3.2. Sensory Device

Five sensors are included with the sensory device to measure air pollution. The temperature, humidity, and pressure sensors-three crucial air quality sensors are described in detail in Table 1.

A cheap dust sensor module with exceptional sensitivity, the DSM501A can identify microscopic particles larger than one micrometer in diameter. The MQ9 sensor has a long lifespan, a straightforward drive circuit, and is especially sensitive to flammable gasses and carbon monoxide.

As the quantities of gases in the air rise, so does the conductivity of the sensors. The MQ135 sensor has a broad detection range and a quick response time for NH_3, alcohol, CO_2, smoke, and other chemicals. The DHT22 is a temperature and relative humidity sensor that has a digital output and four pins of resistivity. Last but not least, the inexpensive BMP180 sensor doubles as an altimeter by tracking variations in air pressure that correlate with elevation changes.

Table 1. Sensor's specification

Parameter	Operating Voltage	Measuring Range
Temperature	5V	-10°C to 40°C
Humidity	1.5V	0% to 100%
Pressure	3.3V	900 hPa to 1100 hPa
Dust (DSM501A)	2.7V	Fine Particles > 1 micron
Carbon Monoxide	4V	Combustible Gases
MQ135 (Gas)	5V	NH3, Alcohol, CO_2, Smoke, etc
Relative Humidity	3.3V	Digital Output
Barometric Pressure	5V	Altitude Changes

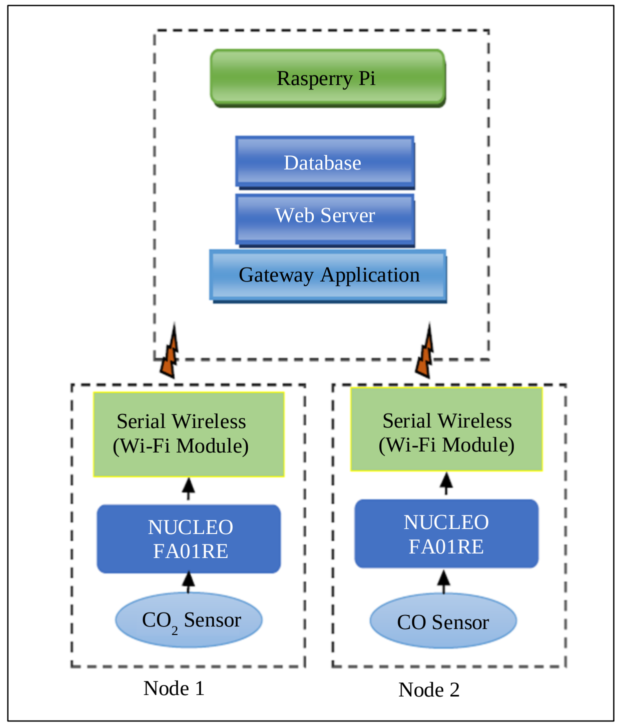

Fig. 2 System architecture

3.3.3. MQ-Gas Sensor

The component outlined below is the forefront of laboratory IoT systems, typically referred to as the "Things" in the system. Their major task is to either gather environmental data from their surroundings, such as sensors or disseminate data to their surroundings, such as actuators. These low-cost semiconductor sensors are especially well-suited for array deployment, making them essential components of cost-effective environmental pollution monitoring systems.

The potential of such an array can be expanded by adding sensors for temperature, pressure, and relative humidity. This enlarged sensor array not only measures pollution concentrations but also gives useful information on other critical physical characteristics.

Adding these additional sensors improves overall system calibration, ensuring the accuracy and dependability of the gas sensors in analyzing environmental conditions. This collaborative approach helps to build comprehensive and cost-effective solutions for monitoring and maintaining environmental quality.

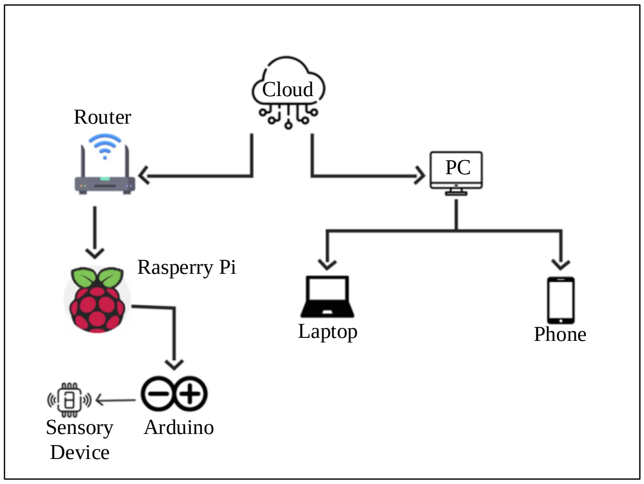

Fig. 3 System proposal

4. Methodology

This sensor-based pollution-related monitoring system has a cheap cost, high accuracy, and user-friendly design. The DHT22 and BMP180 are connected to the Arduino's digital pins 3 and 4, while the DSM501A PM sensor is connected to digital pin 5 of the Arduino. Additionally, the Arduino's analog pins 2 and 3 are linked to the MQ135 and MQ9 sensors.

The Raspberry Pi and Arduino connect with one another via a USB cord. Via a USB connector, the Raspberry Pi and the Wi-Fi adaptor that connects it to the internet can communicate. Installing the operating system on the Raspberry Pi begins with downloading the image from the official website.

Once the file.zip has been downloaded and unzipped, the.img image is extracted and stored on the SD card. Although the Raspbian Jessie version preconfigures the SD card image with Node-RED as of November 2015, an upgrade may still be required. The command "sudo systemctl enable nodered.service" starts Node-RED automatically when the Raspberry Pi boots up.

Users must first create an account on IBM Bluemix and register the device to enjoy IBM cloud services. Once registered, the Bluemix IoT platform offers an authentication token for data transfer from the device to the Bluemix IoT platform. The Raspberry Pi is interfaced with the Arduino because the sensors are already linked to the Arduino board.

Developing a flow that connects the Watson IoT node to the Serial In node for data transfer to the cloud and a Serial In node for receiving data from the Raspberry Pi's serial port. All you need is an internet-connected device to access the gathered data on the IBM Bluemix IoT platform dashboard from anywhere in the globe. High accuracy, cost, and user-friendliness are guaranteed by the sensor-based air quality monitoring system, which makes use of the DSM501A PM sensor and additional sensors. The core hub is the Raspberry Pi, which communicates with Arduino and allows data to be sent to the IBM Bluemix IoT platform.

4.1. Testing on PC for Central Prediction Evaluation and Raspberry Pi 4 for Edge Prediction

The suggested NARX architecture is rigorously tested and evaluated to ensure its effectiveness in central prediction scenarios. This rigorous testing is done on a regular Personal Computer (PC), providing information about the architecture's performance under standard computational settings. The findings of this central prediction evaluation on a PC provide a baseline for evaluating the architecture's capabilities in a controlled setting. The NARX architecture is implemented and tested on a Raspberry Pi 4 platform in all of the central prediction scenarios.

This technique evaluates the architecture's efficiency and usefulness for edge prediction situations involving resource restrictions and distributed computing environments. The Raspberry Pi 4, with its small form factor and limited processing resources, serves as a model for edge computing, providing significant insights into the NARX architecture's adaptability to such constrained environments. A thorough discussion is held about the computational efficiency and resource utilization of the proposed NARX architecture in both central and edge computing settings.

The findings from testing on a PC and a Raspberry Pi 4 provide a comprehensive view of the architecture's performance range. Processing speed, memory utilization, and energy efficiency are all evaluated to assess whether the architecture is suitable for deployment in various computing situations.

This testing technique not only proves the NARX architecture's robustness but also demonstrates its adaptability to various computational contexts. The goal of the computational efficiency discussion is to offer helpful suggestions to researchers and practitioners who want to apply the NARX architecture in a range of scenarios, from resource-constrained edge computing applications to centralized prediction scenarios.

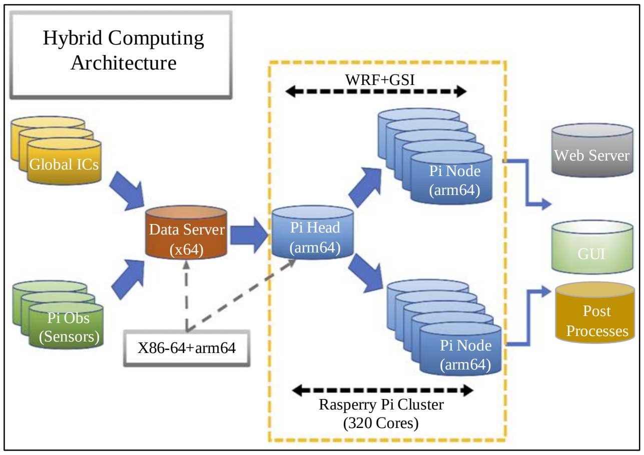

Fig. 4 Raspberry prediction system

5. Result of the Study

The proposed air quality monitoring system, which combines IoT and cloud computing, represents a strategic convergence of technological breakthroughs. Large sensor arrays, effective communication networks, and Raspberry Pis are used in a more comprehensive way to monitor air quality, which opens the door to improved pollution control and public awareness.

The study's findings highlight how well the designed air quality monitoring system works as a comprehensive approach to pollution control and raising public awareness. Integrating IoT, cloud computing, and the Raspberry Pi 4 Model B positions the system as a technologically advanced yet accessible and cost-effective tool. As air quality continues to be a global concern, the study's findings emphasize the importance of comprehensive, data-driven solutions in safeguarding human health, environmental sustainability, and the well-being of communities.

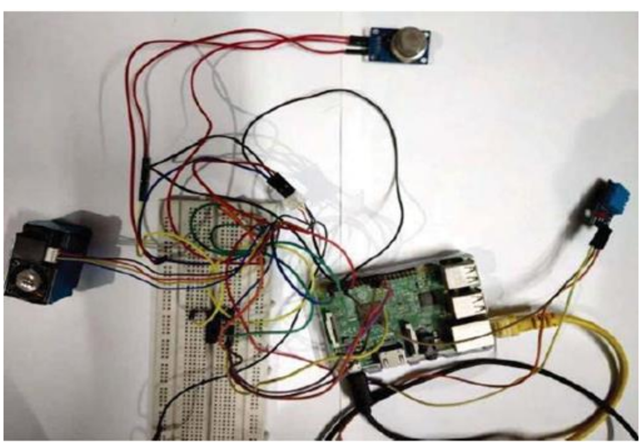

Fig. 5 Hardware system setup

Depicts the visual representation of this approach's seamless integration and analysis flow using Node-RED, a strong visual programming tool. This graphic representation captures this system's intricate actions and connections, demonstrating the efficiency and clarity gained from this intuitive programming environment. This stage is critical in the air quality management system since the insights gained from individual devices contribute to a more complete picture of overall environmental conditions. Figure 4 provides a clear visual picture of the device-centric analytical process, stressing the importance of each device's contribution to the larger context of Somalia's air quality monitoring in Somalia.

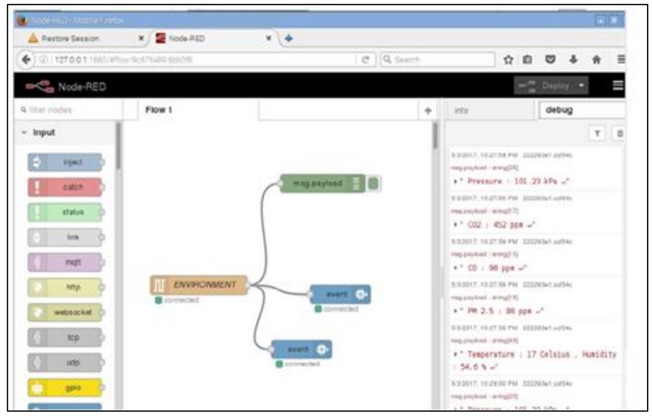

Fig. 6 Node-RED flow of system

Figure 6 depicts a thorough view of the metrics displayed on the dashboard, emphasizing the complexity and diversity of the data. The IBM Watson platform's various visually appealing designs allow a fascinating presentation of these parameters. The complexities of the air quality data are beautifully visualized on the dashboard, which improves the entire user experience. The IBM Watson platform's different designs add to its visual appeal and play an important role in transmitting complex environmental information in an accessible and intuitive manner. The visually appealing dashboard provides a useful interface for users, allowing them to analyze and gain insights from the given parameters easily. This careful design approach improves the performance of the air quality control system by increasing user participation and developing a better awareness of Somalia's environmental circumstances.

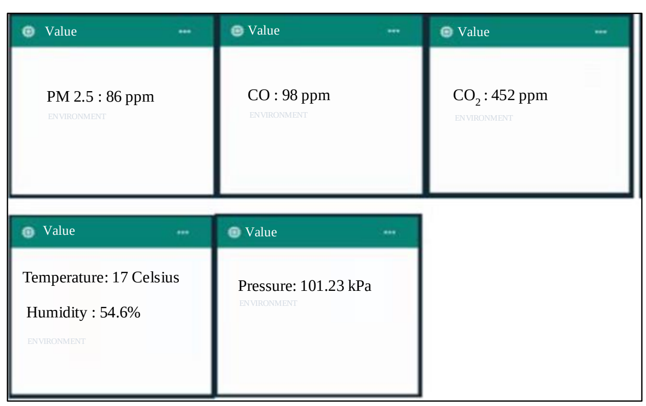

Fig. 7 System first screening

Table 2 presents a full overview of the values acquired from several sensors during the morning. This information is an essential component of this air quality monitoring system, providing a specific picture of environmental conditions during this critical time of day. The figures in the table represent the wide range of parameters tracked by the sensors, offering a full understanding of the air quality dynamics. The graph below shows the air quality based on the system.

Table 2. System measurement value results

Kind of Sensor	Value Measured	Expected Outcome
CO_2 (ppm)	388	403
Pressure in K-Pascal	167.01	169.94
PM 2.5 Model (ppm)	194	198
CO in Model (ppm)	347	362
Temperature (°C)	21	22
Relative Humidity (%)	60.1	62

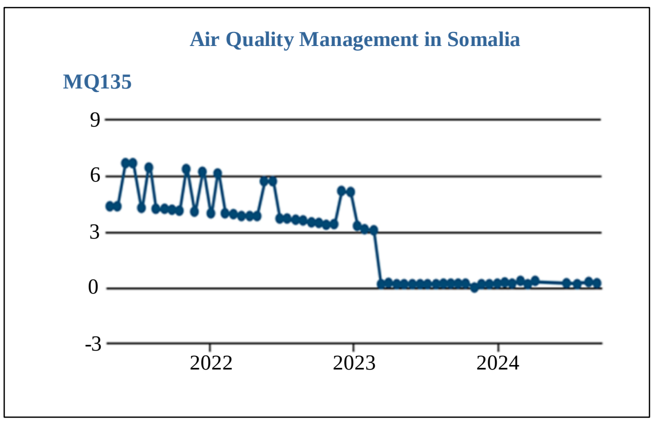

Fig. 8 Air quality graph based on the system

6. Conclusion

The study highlights the critical importance of addressing air pollution in Somalia due to its serious impact on human health, ecosystems, and overall sustainability. The absence of detailed data for Somalia highlights the importance of conducting comprehensive studies to identify the scope of the problem and implement effective solutions. Public awareness efforts and international collaborations have been acknowledged as critical aspects in reducing air pollution and creating a better environment for Somalis.

The designed air quality monitoring system, which includes the DSM501A PM2.5 sensor, Raspberry Pi, IoT, and cloud computing, is a significant technological achievement. The ability of the device to assess particulate matter and other environmental indicators gives a more comprehensive and nuanced approach to air quality monitoring. The versatility and efficiency of the Raspberry Pi, together with the power of IoT and cloud computing, create a solid foundation for real-time data collecting, analysis, and presentation.

The significance of including particulate matter detection in air quality monitoring frameworks is that these small particles significantly influence cardiovascular and respiratory systems. The combination of IoT with cloud computing shows to be a powerful tool, allowing for improved data accessibility, real-time analysis, and the development of prediction models for effective pollution management.

The system's commitment to affordability and energy efficiency, together with its global deployment potential, offers it a viable option for places experiencing various environmental concerns. The incorporation of environmental awareness features and user-friendly interfaces develops a sense of environmental responsibility, encouraging communities to actively participate in addressing pollution challenges.

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